Data Mining in Radiation Portal Monitoring

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Currently deployed passive gamma and neutron detectors screen for illicit nuclear material. Archived data can help to evaluate detection probabilities (DP) and to investigate several issues, including: 1) background gamma suppression, 2) nuisance gamma alarms arising from naturally occurring radiation (NORM), and 3) the state of sensor health.

Figure 1 shows one screening location, where four detector panels each record a neutron and a low- and high-energy gamma count every 0.1 s for 5 to 20 s, resulting in a 12-component time series of 50 to 200 observations.

Figure 2 (top left) is an example of the raw and smoothed scaled low-energy gamma count time series ("profile") from one vehicle. Figure 2 (top left) illustrates background suppression, which modeling suggests arises from displacement of the air from which background gammas arise, and from shielding nearby ground sources such as asphalt. Threat detection algorithms that rely on anticipated profile shapes must consider the effect of background suppression. Several options to adjust for background suppression have been evaluated [1-3]. Note from Fig. 2 (bottom left) that simply subtracting the average background suppression (the "template," with alignment to adjust for unequal profile lengths) results in undesirable patterns in the residuals. One advantage of monitoring count ratios is that their suppression is less (right side plots in Fig. 2).

Nuisance alarms due to NORM limit DP for threats. Strategies to recognize common NORM such as cat litter or ceramics depend on the sensor energy resolution. One of the best methods using the systems described here (two-energy gamma and neutron) uses a nonparametric density estimation method for pattern recognition [4-5].

Sensor health can be monitored using periodic check-source measurements, but because the unshielded background changes over time due to environmental changes, archived data is a potential quality control (QC) component to flag measurement anomalies. One QC option is to monitor count ratios. For example, using training data from December 1-15, 2003, from one site, and testing data from January-March of 2005, a nominal 1% false alarm rate derived from selecting ratio alarm thresholds from the training data had an actual false alarm rate of 1 to 40% in the testing data, thus indicating nonstationarity [6].

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[1] J. Gattiker and T. Burr, to appear in *Journal of Nucl. Mater. Management* (2008).
[2] T. Burr et al., *Applied Radiation and Isotopes,* **65,** 569–580 (2007).
[3] T. Burr et al., "Statistical Evaluation of the Impact of Background Suppression on the Sensitivity of Passive Radiation Detectors," in *Statistical Methods in Counter Terrorism,* New York: Springer (2006).
[4] T. Burr and K. Myers, to appear in *Applied Radiation and Isotopes* (2008).
[5] T. Burr and J. Doak, *Intelligent Data Analysis,* **11,** 651-662 (2007).
[6] P. Doctor et al., "Evaluation of State of Health Monitoring for Radiation Portal Monitors," PNNL-SA-4875 (2006).

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Fig. 1. Example screening location with four detector panels surrounding the vehicle.

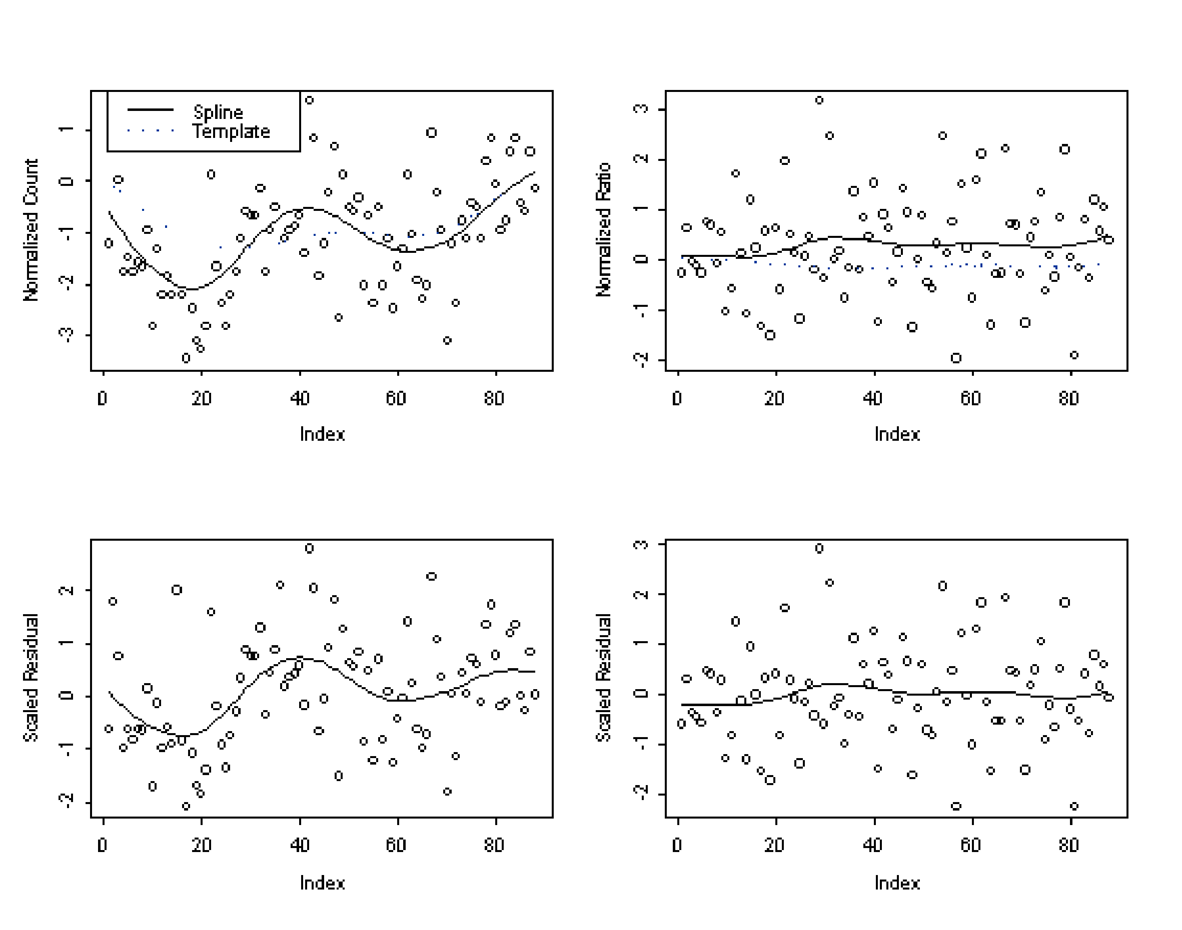

Fig 2. (top left) Example scaled low-energy gamma profile from one vehicle, a spline fit, and an average ("template") over many vehicles; (top right) same as top left, but for the gamma count ratio (defined as low-energy gamma count)/total gamma count); (bottom left) scaled residual from the count, and (bottom right) scaled residual from the count ratio.